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PATENT ABSTRACTS OF JAPAN

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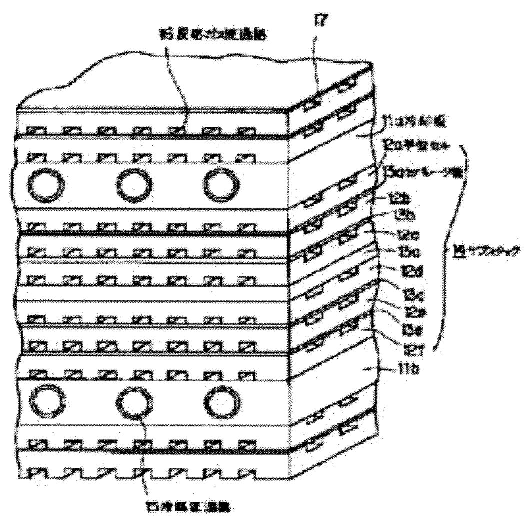
(54) FUEL CELL

(57)Abstract:
PURPOSE: To provide a fuel cell which is excellent in power generating efficiency and by which stable and high fuel cell performance can be maintained over a long period of time and which has the long service life by uniformizing temperature distribution of a sub-stack, and setting an operation temperature of the whole laminated body at a temperature closer to an allowable temperature.
CONSTITUTION: Plural unit cells 12a-12f and separator plates 13a-13e are laminated alternately upon each other, and a sub-stack 14 is formed. The sub-stack 14 and cooling plates 11a and 11b are laminated in a plurality alternately upon each other, and a laminated body is formed. A thickness of the separator plate 13c in the laminating directional central part of the sub-stack 14 is made thicker than the other part. Or a cross-sectional area or a gas contact area of a reaction gas flow passage of a unit cell 12c in the laminating directional central part of the sub-stack 14 is made larger than the other part. Or a heat radiating plate 21 is interposed between the unit cells 12c and 12d in the laminating directional central part of the sub-stack.



CLAIMS

[Claim(s)]
[Claim 1]An electrode of a couple which forms a reactant gas circulation way in a field of another side while making one field of an electrode substrate support a catalyst, Make those catalyst surfaces counter, arrange and a unit cell is formed across an electrolyte layer between catalyst surfaces of an electrode of this couple, In a fuel cell which laminates two or more these unit cells, inserts a separator board, respectively, forms sub stacks between each unit cell, laminates two or more these sub stacks and cold plates by turns, and forms a layered product, A fuel cell making thickness of a separator board of a lamination direction center section of said sub stacks thicker than thickness of a separator board of other portions.
[Claim 2]An electrode of a couple which forms a reactant gas circulation way in a field of another side while making one field of an electrode substrate support a catalyst, Make those catalyst surfaces counter, arrange and a unit cell is formed across an electrolyte layer between catalyst surfaces of an electrode of this couple, In a fuel cell which laminates two or more these unit cells, inserts a separator board, respectively, forms sub stacks between each unit cell, laminates two or more these sub stacks and cold plates by turns, and forms a layered product, A fuel cell making a cross-section area or a gas touch area of a lamination direction center section of a reactant gas circulation way larger than other cross-section areas or gas touch areas of a reactant gas circulation way of a portion. [of said sub stacks] [of a unit cell] [of a unit cell]
[Claim 3]An electrode of a couple which forms a reactant gas circulation way in a field of another side while making one field of an electrode substrate support a catalyst, Make those catalyst surfaces counter, arrange and a unit cell is formed across an electrolyte layer between catalyst surfaces of an electrode of this couple, In a fuel cell which laminates two or more these unit cells, inserts a separator board, respectively, forms sub stacks between each unit cell, laminates two or more these sub stacks and cold plates by turns, and forms a layered product, A fuel cell making at least one heat sink intervene between unit cells of a lamination direction center section of said sub stacks.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]This invention relates to the technology for improving the generation efficiency of a fuel cell by equalizing the temperature distribution between two or more unit cells which start a fuel cell, especially constitute a fuel cell layered product, and preventing a local rise in heat.
[0002]
[Description of the Prior Art]A fuel cell is equipment which transforms into electrical energy directly the energy released with oxidation reaction by oxidizing the fuel which has chemical energy in the Electrochemistry Sub-Division process. Since there is the feature that the thermal efficiency of power generation reaches also to 40 to 50%, also on a scale of being comparatively small, this fuel cell generation system is expected as an efficient power generation system which easily endures a new thermal power system. There is also an advantage with very little discharge of SOx and NOx which are the public nuisance factor which is a big social problem in recent years not needing a lot of cooling water since a combustion cycle is not included in a power plant, and that there are few environmental problems, such as noise and exhaust gas, since there are the features, like vibration is small. Since a response is good, and high conversion efficiency can be theoretically expected to a load change and there is the feature which was excellent in having turned to the cogeneration system which also uses heat simultaneously with power generation etc., it has expectation and an interest in the research and development, and is pressing for utilization at hand.
[0003]As this kind of a fuel cell, what was shown in JP,S60-93765,A is known, for example. Namely, as shown in drawing 8, a cell proper, Between the layered product 1 which laminates many cold plates for discharging the heat generated in the unit cell and this unit cell for power generation, the clamping plate 2 which binds that layered product 1 tight from up-and-down both sides, and the layered product 1 and the clamping plate 2. It has the sealant 5 which carries out the seal of between the spacer 3 to insert, the gas manifold 4 for reactant gas supply / discharge, the gas manifold 4, and the layered products 1.
[0004]Such a cell proper is further provided with the refrigerant manifold for refrigerant supply and discharge which is not illustrated, the busbar for electric-generating-power drawing which is not illustrated, etc. And the fuel gas and oxidant gas which are reactant gas are supplied and discharged by the unit cell of the layered product 1 from the outside via the gas manifold 4, and refrigerants, such as water, are supplied and discharged from the outside via a refrigerant manifold at the cold plate of the layered product 1.
[0005]Generally, the layered product 1 of the above fuel cells laminates two or more unit cells, inserts the separator board which classifies reactant gas between each unit cell, respectively, forms one sub stacks, laminates such two or more sub stacks and cold plates by turns, and is constituted. In this case, the unit cell which constitutes the layered product 1 makes those catalyst surfaces counter, arranges the porous electrode of the couple which forms a reactant gas circulation way in the field of another side, and is usually formed across an electrolyte layer between these catalyst surfaces while it makes one field of an electrode substrate support a

catalyst. And while contacting fuel gas, such as hydrogen, at the back by using one electrode as a fuel electrode, Oxidant gas, such as oxygen, is contacted at that back by making the electrode of another side into an oxidizing agent pole, and it is constituted so that the electrical energy generated according to the electrochemical reaction which occurs at this time may be taken out from inter-electrode [of the above-mentioned couple]. A refrigerant flowing path is formed in a cold plate, and by circulating a refrigerant here, it is constituted so that the unit cell of the cold plate circumference may be cooled.

[0006]As for a standard and unification, size form of the outside and reactant gas circulation way of two or more unit cells which constitute the layered product 1, size form of a separator board, size form of a cold plate and its refrigerant flowing path, etc. are made all, respectively from a viewpoint [carry out facilitating of the structure to details, and] of improving reliability and productivity to them more. Generally acidic solutions, such as phosphoric acid, are used as an electrolyte. Many parallel slots are formed in the field of another side as a reactant gas circulation way, and the porous electrode of a unit cell is constituted while usually using a porous carbon base substance like carbon paper as an electrode substrate and making one field of this porous carbon base substance support a precious metal catalyst.

[0007]

[Problem to be solved by the invention]By the way, in the above conventional fuel cells, Since a gap is produced to the temperature between two or more unit cells which constitute the layered product 1, when a maximum temperature is set below to permissive temperature, it must operate at low temperature about most unit cells more than needed, and, as a result, there is a problem that generation efficiency becomes low. This point is explained below.

[0008]That is, since the electrochemical reaction of a unit cell which was mentioned above is first promoted so that the operating temperature of a unit cell is high, fundamentally, the generation efficiency of a fuel cell becomes so large that the operating temperature of a unit cell is high. However, if a value with the operating temperature of a unit cell is exceeded, battery capacity will fall rapidly by degradation of a catalyst and an electrolytic reduction which promote electrochemical reaction, and a battery life will become short. For this reason, it is necessary to set up and hold the maximum temperature in a unit cell below at a certain value.

[0009]On the other hand, as mentioned above, the layered product 1 of a fuel cell laminates much sub stacks constituted by the separator board inserted between two or more unit cells and each unit cell a cold plate and by turns, and is constituted, but generally the temperature in sub stacks serves as uneven and three-dimensional distribution. Concretely, the temperature distribution of the lamination direction in near the center of the unit-cell flat surface in the sub stacks between cold plates comes to be shown in B of drawing 3. As shown in B of this drawing 3, the temperature of the unit cell is high in inclination toward the lamination direction end of sub stacks to the lamination direction center section. And the temperature of the unit cell of a lamination direction center section, i.e., the unit cell in the furthest position from a cold plate, is the highest, and this maximum-temperature t_2 is very high compared with mean-temperature t_0 of sub stacks. For example, when the amount of reactant gas of a fixed capacity factor is supplied to a layered product by the loaded condition of 200 mA/cm^2, it is checked to mean-temperature t_0 being 200 ** that maximum-temperature t_2 has gone up to 215 **.

[0010]When a constant temperature line (T1-T6) shows the temperature distribution within the flat surface of such a unit cell of a lamination direction center section, it comes to be shown in (B) of drawing 2. near a unit-cell center has a small interval of a constant temperature line, namely, the temperature gradient is large, and the narrow field in the constant temperature line T6 is [/ else] markedly alike, and turns into a hot maximum-temperature field so that clearly from this drawing 2. Therefore, in the conventional fuel cell, as temperature (maximum temperature) of the maximum-temperature field where the unit cell of this lamination direction center section is narrow is made below into permissive temperature, values, such as circulating water temperature, will be set up. therefore, since it will be markedly alike compared with the mean temperature of the whole layered product and a high temperature will be set below to permissive temperature, it results in operating many unit cells by the side of the lamination

direction end of sub stacks at low temperature more than needed. Corresponding [namely,] to the size of the temperature gradient between two or more unit cells which constitute sub stacks, and the size of the temperature gradient in the unit cell of the lamination direction center section which has a maximum-temperature field, About most unit cells, a result operated at a temperature far lower than permissive temperature is brought, and this serves as trouble of improvement in generation efficiency. When it runs continuously over a long period of time by degradation of the catalyst in a local hot section, as shown in drawing 4, battery capacity will fall greatly.

[0011]this invention is proposed in order to solve SUBJECT of the above conventional technologies, and it comes out. By the purpose's losing a local hot section in a sub-stacks center section of **, equalizing temperature distribution of sub stacks, and enabling setting out of an operating temperature of the whole layered product to a near temperature with permissive temperature, It is providing a long fuel cell of a battery life which is excellent in generation efficiency and can maintain high battery capacity stable over a long period of time.

[0012]

[Means for solving problem]A fuel cell of this invention an electrode of a couple which forms a reactant gas circulation way in a field of another side while making one field of an electrode substrate support a catalyst, Make those catalyst surfaces counter, arrange and a unit cell is formed across an electrolyte layer between catalyst surfaces of an electrode of this couple, Two or more these unit cells are laminated, between each unit cell, a separator board is inserted, respectively and sub stacks are formed, and two or more these sub stacks and cold plates are laminated by turns, and it has the following features in a fuel cell which forms a layered product.

[0013]First, the fuel cell according to claim 1 is characterized by making thickness of a separator board of a lamination direction center section of said sub stacks thicker than thickness of a separator board of other portions. The fuel cell according to claim 2 is characterized by making a cross-section area or a gas touch area of a lamination direction center section of a reactant gas circulation way larger than other cross-section areas or gas touch areas of a reactant gas circulation way of a portion. [of said sub stacks] [of a unit cell] [of a unit cell] The fuel cell according to claim 3 is characterized by making at least one heat sink intervene between unit cells of a lamination direction center section of said sub stacks.

[0014]

[Function]The operation of this invention which has the above composition is as follows. First, in the fuel cell according to claim 1, By having made thickness of the separator board of the lamination direction center section of sub stacks thicker than other portions, with this separator board, heat conduction of the lamination direction between the unit cells of those both sides can be controlled, and only that part can promote heat conduction of the plane direction of a unit cell. As a result, the temperature distribution in the unit cell of the lamination direction center section which has a maximum-temperature field is equalized, and since the temperature of the maximum-temperature field in this unit cell can be reduced and it can bring close to the mean temperature of the whole layered product, the temperature distribution between two or more unit cells which constitute a layered product can be equalized. Therefore, when the maximum-temperature field of the unit cell of a lamination direction center section is set below to permissive temperature, the operating temperature of the whole layered product can be close brought with permissive temperature, and, thereby, generation efficiency can be improved. Since a local hot section can be lost, degradation of a catalyst can be controlled and the high battery capacity stable over the long period of time can be maintained.

[0015]Next, in the fuel cell according to claim 2, By having made the cross-section area or gas touch area of the lamination direction center section of the reactant gas circulation way larger than other portions, the unit cell of a lamination direction center section can be cooled by reactant gas circulation in this reactant gas circulation way. [of sub stacks] [of the unit cell] As a result, the temperature of the unit cell of the lamination direction center section which has a maximum-temperature field can be reduced, and the temperature distribution between two or more unit cells which constitute a layered product can be equalized. Therefore, when the

maximum-temperature field of the unit cell of a lamination direction center section is set below to permissive temperature, the operating temperature of the whole layered product can be close brought with permissive temperature, and, thereby, generation efficiency can be improved. Since a local hot section can be lost, degradation of a catalyst can be controlled and the high battery capacity stable over the long period of time can be maintained.
[0016]In the fuel cell according to claim 3, the unit cell of a lamination direction center section can be cooled by this heat sink by having made the heat sink intervene between the unit cells of the lamination direction center section of sub stacks. As a result, the temperature of the unit cell of the lamination direction center section which has a maximum-temperature field can be reduced, and the temperature distribution between two or more unit cells which constitute a layered product can be equalized. Therefore, when the maximum-temperature field of the unit cell of a lamination direction center section is set below to permissive temperature, the operating temperature of the whole layered product can be close brought with permissive temperature, and, thereby, generation efficiency can be improved. Since a local hot section can be lost, degradation of a catalyst can be controlled and the high battery capacity stable over the long period of time can be maintained.
[0017]
[Working example]
(1) Describe concretely one embodiment (the 1st embodiment) of the fuel cell by the invention according to claim 1 less than to the 1st embodiment with reference to drawing 1 thru/or drawing 4. Here, drawing 1 is a perspective view showing typically a part of layered product of a fuel cell. Drawing 2 is a figure showing the temperature distribution within the flat surface of the unit cell of the lamination direction center section in the sub stacks with a constant temperature line in comparison about the fuel cell of drawing 1, and the conventional fuel cell, respectively. (A) of drawing 2 is the thermal mapping of the unit-cell flat surface of the fuel cell of drawing 1, and (B) is the thermal mapping of the unit-cell flat surface of the conventional fuel cell.
The graph and drawing 4 which drawing 3 shows the temperature distribution of the lamination direction in near the center of the unit-cell flat surface in the sub stacks in comparison about the fuel cell A of drawing 1 and the conventional fuel cell B, It is a graph which shows the battery capacity to operation time in comparison about the fuel cell A of drawing 1, and the conventional fuel cell B.
[0018]First, as shown in drawing 1, among the adjoining cold plates 11a and 11b, the sub stacks 14 which laminate the six unit cells 12a-12f and the five separator boards 13a-13e by turns are arranged. The thickness of the separator board 13c of a lamination direction center section inserted between the two unit cells 12c and 12d of the lamination direction center section of the sub stacks 14 among the separator boards 13a-13e which constitute the sub stacks 14, The thickness of other separator boards 13a, 13b, 13d, and 13e is thick to 3 or more times, and it is carried out. 15 in a figure is the refrigerant flowing path established in the cold plates 11a and 11b.
16 and 17 are the reactant gas circulation ways established in the unit cells 12a-12f.

[0019]The operation of this example which has the above composition is as follows. That is, at the time of operation of a fuel cell, the heat generated from each unit cells 12a-12f moves in three dimensions in the inside of the sub stacks 14 which comprise the unit cells 12a-12f and the separator boards 13a-13e, and is absorbed by the cold plates 11a and 11b in the both ends of the sub stacks 14. At this time, since the calorific value in each unit cell is generally uneven, like before when the thickness of the separator boards 13a-13e is equal, unit cells [of a lamination direction center section / 12c and 12d] temperature will become the highest, and as shown in (B) of drawing 2, further, it is narrow, and rather than the mean temperature of the whole layered product, area will resemble the flat surface of the unit cell markedly, and will produce a hot maximum-temperature field at it.
[0020]On the other hand, since thickness of other separator boards 13a, 13b, 13d, and 13e is thick to 3 or more times and thickness of the separator board 13c of a lamination direction center section of the sub stacks 14 is carried out in this example, With this separator board 13c,

heat conduction of the unit cell 12c of those both sides and a lamination direction between 12d can be controlled, and only that part can promote heat conduction of a unit cells [12c and 12d] plane direction. Therefore, as shown in (A) of drawing 2, lose the local hot section T6 in the unit cell 12c of a lamination direction center section, and a plane direction in 12d, and temperature distribution is equalized, Temperature of this unit cell 12c and a maximum-temperature field in 12d can be reduced from conventional T6 to T5, and can be brought close to mean temperature of the whole layered product.

[0021]By the way, temporarily, when all the separator boards 13a-13e are thickened, horizontal heat conduction is promoted further and equalize temperature distribution of a plane direction of a unit cell further, but. On the other hand, height of the whole layered product becomes high, and it can not only become disadvantageous on transportation or earthquake-proof, but thermal resistance of a lamination direction becomes large and it cannot necessarily lower a maximum temperature in a cell. On the other hand, since heat conduction of a lamination direction is symmetrically performed up and down considering a separator of a center section as a center like an embodiment shown in drawing 1 when the number of unit cells between the cold plate 11a and 11b is even, Even if it thickens only a separator board of a center section, it does not become the increase in thermal resistance of a lamination direction, but as mentioned above, an effect of heat-conduction promotion of a plane direction of a unit cell can act effectively, and can reduce a maximum temperature of a unit cell.

[0022]Therefore, in this example, since the maximum temperature of a unit cell can be conventionally pressed down low when the temperature of cooling water and the calorific value of a unit cell are the same, the temperature distribution for [of six pieces] unit-cell 12a-12f which constitutes the sub stacks 14 can be equalized. That is, as shown in drawing 3, maximum-temperature t_1 of the unit cell of the lamination direction center section in the sub stacks of the fuel cell A of this example is lower than maximum-temperature t_2 of the conventional fuel cell B. The difference of maximum-temperature t_1 and mean-temperature t_0 of sub stacks is smaller than before.

For example, the conventional fuel cell which made the same standard all the unit cells and separator boards in a lamination direction of sub stacks, About the fuel cell of this example which changed the thickness of the separator board of the lamination direction center section of sub stacks. When the amount of reactant gas of a fixed capacity factor is supplied to each layered product by the loaded condition of 200 mA/cm^2, in the conventional fuel cell. As mentioned above, compared with maximum-temperature t_2 having gone up to 215 ** to mean-temperature [of 200 **] t_0, maximum-temperature t_1 to mean-temperature [of 200 **] t_0 was 205 ** in the fuel cell of this example.

[0023]Thus, since the difference of maximum-temperature t_1 and mean-temperature t_0 in sub stacks can be made smaller than before in this example, when unit cells [of a lamination direction center section / 12c and 12d] maximum-temperature t_1 is set below to permissive temperature, the operating temperature of the whole layered product can be brought close to permissive temperature conventionally, and generation efficiency can be markedly boiled rather than before by that cause, and it can improve. since the local hot section conventionally produced in sub stacks can be lost, when a fuel cell is run continuously over a long period of time, as shown in drawing 4, the fuel cell A of this example is markedly boiled compared with the conventional fuel cell B, and can maintain high battery capacity.

[0024]Although the cold plate 11a and the sub stacks 14 between 11b were constituted from the six unit cells 12a-12f and the five separator boards 13a-13e and the example which makes only the one separator board 13c of a lamination direction center section thicker than others was shown in said 1st embodiment, When it is considered as odd sub stacks between cold plates and a separator board is constituted as even pieces, two central separator boards may be thickened. Namely, since heat transfer of the plane direction of the unit cell of the both sides of this separator board can be promoted when temperature generally thickens one piece or two or more

separator boards near the unit cell of the lamination direction center section which becomes high, Thereby, the temperature distribution of this unit cell is equalized, and a maximum temperature can be reduced conventionally and can be brought close to the mean temperature of the whole layered product.
[0025](2) Describe concretely one embodiment (the 2nd embodiment) of the fuel cell by the invention according to claim 2 less than to the 2nd embodiment with reference to drawing 5. Here, drawing 5 is a perspective view showing typically a part of layered product of a fuel cell. Identical codes are given to said 1st embodiment and identical parts, and explanation is omitted.
[0026]First, as shown in drawing 5, among the adjoining cold plates 11a and 11b, the sub stacks 14 which laminate the five unit cells 12a-12e and the four separator boards 13a-13d by turns are arranged. About the one unit cell 12c of the lamination direction center section of the sub stacks 14, among the unit cells 12a-12e which constitute the sub stacks 14. The tooth depth of the reactant gas circulation way 16 of one of these is made into twice the tooth depth of the reactant gas circulation way 16 where other four unit cells 12a, 12b, 12d, and 12e correspond. Following in the case of this tooth depth, the thickness of the unit cell 12c of a center section is thicker than the thickness of the other unit cells 12a, 12b, 12d, and 12e. The tooth depth of the reactant gas circulation way 17 of another side of the unit cell 13c is made equal to the tooth depth of the reactant gas circulation way 17 where other unit cells 12a, 12b, 12d, and 12e correspond.
[0027]The operation of this example which has the above composition is as follows. Namely, in this example, a tooth depth of the reactant gas circulation way 16 of the unit cell 12c of a lamination direction center section of the sub stacks 14 as twice of a tooth depth of other unit cells 12a, 12b, 12d, and 12e, Since that cross-section area and a gas touch area are enlarged, the unit cell 12c can be cooled by reactant gas circulation of the reactant gas circulation way 16 of this unit cell 12c. Therefore, like said 1st embodiment, a local hot section in a plane direction in the unit cell 12c of a lamination direction center section is lost, temperature distribution is equalized, and temperature of a maximum-temperature field in this unit cell 12c can be reduced conventionally, and can be brought close to mean temperature of the whole layered product.
[0028]Therefore, since a maximum temperature of a unit cell can be conventionally pressed down low like said 1st embodiment also in this example when temperature of cooling water and calorific value of a unit cell are the same, Temperature distribution between the five unit cells 12a which constitute the sub stacks 14 - 12e can be equalized. That is, as shown in drawing 3, maximum-temperature t_1 of a unit cell of a lamination direction center section in sub stacks of the fuel cell A of this example becomes lower than maximum-temperature t_2 of the conventional fuel cell B, and a difference of maximum-temperature t_1 and mean-temperature t_0 of sub stacks becomes smaller than before. For example, the conventional fuel cell which made the same standard a reactant gas circulation way of all the unit cells in a lamination direction of sub stacks, About a fuel cell of this example which changed a tooth depth of a reactant gas circulation way of a unit cell of a lamination direction center section of sub stacks. When the amount of reactant gas of a fixed capacity factor is supplied to each layered product by loaded condition of 200 mA/cm^2, in the conventional fuel cell. As mentioned above, compared with maximum-temperature t_2 having gone up to 215 ** to mean-temperature [of 200 **] t_0, maximum-temperature t_1 to mean-temperature [of 200 **] t_0 was 205 ** like said 1st embodiment in a fuel cell of this example.
[0029]Thus, since the difference of maximum-temperature t_1 and mean-temperature t_0 in sub stacks as well as said 1st embodiment can be made smaller than before also in this example, when maximum-temperature t_1 of the unit cell 12c of a lamination direction center section is set below to permissive temperature, the operating temperature of the whole layered product can be brought close to permissive temperature conventionally, and generation efficiency can be markedly boiled rather than before by that cause, and it can improve. like said 1st embodiment, since the local hot section conventionally produced in sub stacks can be lost, when a fuel cell is

run continuously over a long period of time, as shown in drawing 4, the fuel cell A of this example is markedly boiled compared with the conventional fuel cell B, and can maintain high battery capacity.
[0030]In said 2nd embodiment, although the example which enlarged the tooth depth of one reactant gas circulation way 16 of the unit cell 12c of a lamination direction center section was shown, the form which enlarged the channel depth and the flute width simultaneously, the form which enlarged only the flute width, etc. are possible. That is, in invention of Claim 2, all shape changes that enlarge the cross-section area or gas touch area of the reactant gas circulation way are possible about the unit cell of a lamination direction center section, and the same operation effect as said embodiment can be obtained.
[0031](3) Describe concretely one embodiment (the 3rd embodiment) of the fuel cell by the invention according to claim 3 less than to the 3rd embodiment with reference to drawing 6 and drawing 7. Here, the perspective view in which drawing 6 shows typically a part of layered product of a fuel cell, and drawing 7 are the perspective views showing the heat sink of drawing 6 typically. Identical codes are given to said 1st and 2nd embodiment and identical parts, and explanation is omitted.
[0032]First, as shown in drawing 6, among the adjoining cold plates 11a and 11b, the sub stacks 14 which laminate the six unit cells 12a-12f are arranged. The one heat sink 21 is inserted between the two unit cells 12c and 12d of the lamination direction center section of these sub stacks 14. This heat sink 21 comprises an electrode substrate of the porous electrode of a unit cell, and same porous carbon base substance. And as shown in drawing 7, the reactant gas circulation way 22 is formed in one side of such a heat sink 21 of porosity nature.
The seal part 23 is formed in heat sink 21 end equivalent to the both sides of this reactant gas circulation way 22, and leak of reactant gas can be prevented now at it.
Between each adjoining unit cell and between the unit cells 12c and 12d and the heat sink 21, the six separator boards 13a-13f are inserted, respectively.
[0033]The operation of this example which has the above composition is as follows. That is, in this example, since the heat sink 21 was inserted between the unit cell 12c of the lamination direction center section of the sub stacks 14, and 12d, the unit cells 12c and 12d of those both sides can be cooled by this heat sink 21. In particular, in this example, since the reactant gas circulation way 22 was established in the heat sink 21, cooling efficiency can be made still higher by reactant gas circulation of this reactant gas circulation way 22. Therefore, like said 1st and 2nd embodiment, lose the local hot section in the unit cell 12c of a lamination direction center section, and the plane direction in 12d, and temperature distribution is equalized, The temperature of this unit cell 12c and the maximum-temperature field in 12d can be reduced conventionally, and can be brought close to the mean temperature of the whole layered product.
[0034]Therefore, since the maximum temperature of a unit cell can be conventionally pressed down low like said 1st and 2nd embodiment also in this example when the temperature of cooling water and the calorific value of a unit cell are the same, The temperature distribution for [of six pieces] unit-cell 12a-12f which constitutes the sub stacks 14 can be equalized. That is, as shown in drawing 3, maximum-temperature t_1 of the unit cell of the lamination direction center section in the sub stacks of the fuel cell A of this example becomes lower than maximum-temperature t_2 of the conventional fuel cell B, and the difference of maximum-temperature t_1 and mean-temperature t_0 of sub stacks becomes smaller than before. For example, about the conventional fuel cell which does not have a heat sink in sub stacks, and the fuel cell of this example which has arranged the heat sink in the lamination direction center section of sub stacks. When the amount of reactant gas of a fixed capacity factor is supplied to each layered product by the loaded condition of 200 mA/cm^2, in the conventional fuel cell. As mentioned above, compared with maximum-temperature t_2 having gone up to 215 ** to mean-temperature [of 200 **] t_0, maximum-temperature t_1 to mean-temperature [of 200 **] t_0 was 205 ** like said 1st and 2nd embodiment in the fuel cell of this example.

[0035]Thus, since the difference of maximum-temperature t_1 and mean-temperature t_0 in sub stacks as well as said 1st and 2nd embodiment can be made smaller than before also in this example, when unit cells [of a lamination direction center section / 12c and 12d] maximum-temperature t_1 is set below to permissive temperature, the operating temperature of the whole layered product can be brought close to permissive temperature conventionally, and generation efficiency can be markedly boiled rather than before by that cause, and it can improve. Since the local hot section conventionally produced in sub stacks can be lost, when a fuel cell is run continuously over a long period of time, like said 1st and 2nd embodiment, as shown in drawing 4, the fuel cell A of this example is markedly boiled compared with the conventional fuel cell B, and can maintain high battery capacity. Since the heat sink 21 of this example is using the electrode substrate of the porous electrode of a unit cell, and the same porous carbon base substance, it also has a function as an electrolyte reservoir which carries out impregnation maintenance of the electrolyte.
[0036]In said embodiment, although the reactant gas circulation way 22 was established in the heat sink 21, the composition which is not limited to this and does not form the reactant gas circulation way 22 is also possible for invention of Claim 3, and operation effect sufficient also in such a case is obtained. The composition which forms the two or more heat sinks 21 in the one sub stacks 14 is also possible.
[0037]
[Effect of the Invention]As explained above. [whether the fuel cell of this invention makes thickness of the separator board of the lamination direction center section of sub stacks thicker than other portions, and] Or. [whether the cross-section area or gas touch area of a lamination direction center section of a reactant gas circulation way is made larger than other portions, and] [of sub stacks] [of a unit cell] Or by improvement of the easy composition of making a heat sink intervene between the unit cells of the lamination direction center section of sub stacks, the local hot section in the sub-stacks center section of the layered product can be eliminated, and the temperature distribution of sub stacks can be equalized. Therefore, since it can carry out setting-out possible [of the operating temperature of the whole layered product] to a near temperature with permissive temperature, the long fuel cell of a battery life which is excellent in generation efficiency compared with the former, and can maintain the high battery capacity stable over the long period of time can be provided.

[Translation done.]

TECHNICAL FIELD

[Industrial Application]This invention relates to the technology for improving the generation efficiency of a fuel cell by equalizing the temperature distribution between two or more unit cells which start a fuel cell, especially constitute a fuel cell layered product, and preventing a local rise in heat.

[Translation done.]

PRIOR ART

[Description of the Prior Art]A fuel cell is equipment which transforms into electrical energy directly the energy released with oxidation reaction by oxidizing the fuel which has chemical energy in the Electrochemistry Sub-Division process. Since there is the feature that the thermal efficiency of power generation reaches also to 40 to 50%, also on a scale of being comparatively small, this fuel cell generation system is expected as an efficient power generation system which easily endures a new thermal power system. There is also an advantage with very little discharge of SOx and NOx which are the public nuisance factor which is a big social problem in recent years not needing a lot of cooling water since a combustion cycle is not included in a power plant, and that there are few environmental problems, such as noise and exhaust gas, since there are the features, like vibration is small. Since a response is good, and high conversion efficiency can be theoretically expected to a load change and there is the feature which was excellent in having turned to the cogeneration system which also uses heat simultaneously with power generation etc., it has expectation and an interest in the research and development, and is pressing for utilization at hand.
[0003]As this kind of a fuel cell, what was shown in JP,S60-93765,A is known, for example. Namely, as shown in drawing 8, a cell proper, Between the layered product 1 which laminates many cold plates for discharging the heat generated in the unit cell and this unit cell for power generation, the clamping plate 2 which binds that layered product 1 tight from up-and-down both sides, and the layered product 1 and the clamping plate 2. It has the sealant 5 which carries out the seal of between the spacer 3 to insert, the gas manifold 4 for reactant gas supply / discharge, the gas manifold 4, and the layered products 1.
[0004]Such a cell proper is further provided with the refrigerant manifold for refrigerant supply and discharge which is not illustrated, the busbar for electric-generating-power drawing which is not illustrated, etc. And the fuel gas and oxidant gas which are reactant gas are supplied and discharged by the unit cell of the layered product 1 from the outside via the gas manifold 4, and refrigerants, such as water, are supplied and discharged from the outside via a refrigerant manifold at the cold plate of the layered product 1.
[0005]Generally, the layered product 1 of the above fuel cells laminates two or more unit cells, inserts the separator board which classifies reactant gas between each unit cell, respectively, forms one sub stacks, laminates such two or more sub stacks and cold plates by turns, and is constituted. In this case, the unit cell which constitutes the layered product 1 makes those catalyst surfaces counter, arranges the porous electrode of the couple which forms a reactant gas circulation way in the field of another side, and is usually formed across an electrolyte layer between these catalyst surfaces while it makes one field of an electrode substrate support a catalyst. And while contacting fuel gas, such as hydrogen, at the back by using one electrode as a fuel electrode, Oxidant gas, such as oxygen, is contacted at that back by making the electrode of another side into an oxidizing agent pole, and it is constituted so that the electrical energy generated according to the electrochemical reaction which occurs at this time may be taken out from inter-electrode [of the above-mentioned couple]. A refrigerant flowing path is formed in a cold plate, and by circulating a refrigerant here, it is constituted so that the unit cell of the cold plate circumference may be cooled.

[0006]As for a standard and unification, size form of the outside and reactant gas circulation way of two or more unit cells which constitute the layered product 1, size form of a separator board, size form of a cold plate and its refrigerant flowing path, etc. are made all, respectively from a viewpoint [carry out facilitating of the structure to details, and] of improving reliability and productivity to them more. Generally acidic solutions, such as phosphoric acid, are used as an electrolyte. Many parallel slots are formed in the field of another side as a reactant gas circulation way, and the porous electrode of a unit cell is constituted while usually using a porous carbon base substance like carbon paper as an electrode substrate and making one field of this porous carbon base substance support a precious metal catalyst.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention]As explained above. [whether the fuel cell of this invention makes thickness of the separator board of the lamination direction center section of sub stacks thicker than other portions, and] Or. [whether the cross-section area or gas touch area of a lamination direction center section of a reactant gas circulation way is made larger than other portions, and] [of sub stacks] [of a unit cell] Or by improvement of the easy composition of making a heat sink intervene between the unit cells of the lamination direction center section of sub stacks, the local hot section in the sub-stacks center section of the layered product can be eliminated, and the temperature distribution of sub stacks can be equalized. Therefore, since it can carry out setting-out possible [of the operating temperature of the whole layered product] to a near temperature with permissive temperature, the long fuel cell of a battery life which is excellent in generation efficiency compared with the former, and can maintain the high battery capacity stable over the long period of time can be provided.

[Translation done.]

TECHNICAL PROBLEM

[Problem to be solved by the invention]By the way, in the above conventional fuel cells, Since a gap is produced to the temperature between two or more unit cells which constitute the layered product 1, when a maximum temperature is set below to permissive temperature, it must operate at low temperature about most unit cells more than needed, and, as a result, there is a problem that generation efficiency becomes low. This point is explained below.
[0008]That is, since the electrochemical reaction of a unit cell which was mentioned above is first promoted so that the operating temperature of a unit cell is high, fundamentally, the generation efficiency of a fuel cell becomes so large that the operating temperature of a unit cell is high. However, if a value with the operating temperature of a unit cell is exceeded, battery capacity will fall rapidly by degradation of a catalyst and an electrolytic reduction which promote electrochemical reaction, and a battery life will become short. For this reason, it is necessary to set up and hold the maximum temperature in a unit cell below at a certain value.
[0009]On the other hand, as mentioned above, the layered product 1 of a fuel cell laminates much sub stacks constituted by the separator board inserted between two or more unit cells and each unit cell a cold plate and by turns, and is constituted, but generally the temperature in sub stacks serves as uneven and three-dimensional distribution. Concretely, the temperature distribution of the lamination direction in near the center of the unit-cell flat surface in the sub stacks between cold plates comes to be shown in B of drawing 3. As shown in B of this drawing 3, the temperature of the unit cell is high in inclination toward the lamination direction end of sub stacks to the lamination direction center section. And the temperature of the unit cell of a lamination direction center section, i.e., the unit cell in the furthest position from a cold plate, is the highest, and this maximum-temperature t_2 is very high compared with mean-temperature t_0 of sub stacks. For example, when the amount of reactant gas of a fixed capacity factor is supplied to a layered product by the loaded condition of 200 mA/cm^2, it is checked to mean-temperature t_0 being 200 ** that maximum-temperature t_2 has gone up to 215 **.
[0010]When a constant temperature line (T1-T6) shows the temperature distribution within the flat surface of such a unit cell of a lamination direction center section, it comes to be shown in (B) of drawing 2. near a unit-cell center has a small interval of a constant temperature line, namely, the temperature gradient is large, and the narrow field in the constant temperature line T6 is [/ else] markedly alike, and turns into a hot maximum-temperature field so that clearly from this drawing 2. Therefore, in the conventional fuel cell, as temperature (maximum temperature) of the maximum-temperature field where the unit cell of this lamination direction center section is narrow is made below into permissive temperature, values, such as circulating water temperature, will be set up. therefore, since it will be markedly alike compared with the mean temperature of the whole layered product and a high temperature will be set below to permissive temperature, it results in operating many unit cells by the side of the lamination direction end of sub stacks at low temperature more than needed. Corresponding [namely,] to the size of the temperature gradient between two or more unit cells which constitute sub stacks, and the size of the temperature gradient in the unit cell of the lamination direction center section which has a maximum-temperature field, About most unit cells, a result operated at a

temperature far lower than permissive temperature is brought, and this serves as trouble of improvement in generation efficiency. When it runs continuously over a long period of time by degradation of the catalyst in a local hot section, as shown in drawing 4, battery capacity will fall greatly.
[0011]this invention is proposed in order to solve SUBJECT of the above conventional technologies, and it comes out. By the purpose's losing the local hot section in the sub-stacks center section of **, equalizing the temperature distribution of sub stacks, and enabling setting out of the operating temperature of the whole layered product to a near temperature with permissive temperature, It is providing the long fuel cell of a battery life which is excellent in generation efficiency and can maintain the high battery capacity stable over the long period of time.

[Translation done.]

MEANS

[Means for solving problem]The fuel cell of this invention the electrode of the couple which forms a reactant gas circulation way in the field of another side while making one field of an electrode substrate support a catalyst, Make those catalyst surfaces counter, arrange and a unit cell is formed across an electrolyte layer between the catalyst surfaces of the electrode of this couple, Two or more these unit cells are laminated, between each unit cell, a separator board is inserted, respectively and sub stacks are formed, and two or more these sub stacks and cold plates are laminated by turns, and it has the following features in the fuel cell which forms a layered product.
[0013]First, the fuel cell according to claim 1 is characterized by making thickness of the separator board of the lamination direction center section of said sub stacks thicker than the thickness of the separator board of other portions. The fuel cell according to claim 2 is characterized by making the cross-section area or gas touch area of a lamination direction center section of a reactant gas circulation way larger than other cross-section areas or gas touch areas of a reactant gas circulation way of a portion. [of said sub stacks] [of a unit cell] [of a unit cell] The fuel cell according to claim 3 is characterized by making at least one heat sink intervene between the unit cells of the lamination direction center section of said sub stacks.

[Translation done.]

OPERATION

[Function]The operation of this invention which has the above composition is as follows. First, in the fuel cell according to claim 1, By having made thickness of the separator board of the lamination direction center section of sub stacks thicker than other portions, with this separator board, heat conduction of the lamination direction between the unit cells of those both sides can be controlled, and only that part can promote heat conduction of the plane direction of a unit cell. As a result, the temperature distribution in the unit cell of the lamination direction center section which has a maximum-temperature field is equalized, and since the temperature of the maximum-temperature field in this unit cell can be reduced and it can bring close to the mean temperature of the whole layered product, the temperature distribution between two or more unit cells which constitute a layered product can be equalized. Therefore, when the maximum-temperature field of the unit cell of a lamination direction center section is set below to permissive temperature, the operating temperature of the whole layered product can be close brought with permissive temperature, and, thereby, generation efficiency can be improved. Since a local hot section can be lost, degradation of a catalyst can be controlled and the high battery capacity stable over the long period of time can be maintained.
[0015]Next, in the fuel cell according to claim 2, By having made the cross-section area or gas touch area of the lamination direction center section of the reactant gas circulation way larger than other portions, the unit cell of a lamination direction center section can be cooled by reactant gas circulation in this reactant gas circulation way. [of sub stacks] [of the unit cell] As a result, the temperature of the unit cell of the lamination direction center section which has a maximum-temperature field can be reduced, and the temperature distribution between two or more unit cells which constitute a layered product can be equalized. Therefore, when the maximum-temperature field of the unit cell of a lamination direction center section is set below to permissive temperature, the operating temperature of the whole layered product can be close brought with permissive temperature, and, thereby, generation efficiency can be improved. Since a local hot section can be lost, degradation of a catalyst can be controlled and the high battery capacity stable over the long period of time can be maintained.
[0016]In the fuel cell according to claim 3, the unit cell of a lamination direction center section can be cooled by this heat sink by having made the heat sink intervene between the unit cells of the lamination direction center section of sub stacks. As a result, the temperature of the unit cell of the lamination direction center section which has a maximum-temperature field can be reduced, and the temperature distribution between two or more unit cells which constitute a layered product can be equalized. Therefore, when the maximum-temperature field of the unit cell of a lamination direction center section is set below to permissive temperature, the operating temperature of the whole layered product can be close brought with permissive temperature, and, thereby, generation efficiency can be improved. Since a local hot section can be lost, degradation of a catalyst can be controlled and the high battery capacity stable over the long period of time can be maintained.

[Translation done.]

EXAMPLE

[Working example]
(1) One embodiment of the fuel cell according to the invention according to claim 1 less than in the 1st embodiment

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The perspective view showing typically a part of layered product of the 1st embodiment of the fuel cell by this invention.
[Drawing 2]it is a figure which boils comparatively the temperature distribution within the flat surface of the unit cell of the lamination direction center section in the sub stacks, and is shown with a constant temperature line about the fuel cell of drawing 1, and the conventional fuel cell, respectively -- (A) -- the thermal mapping of the unit-cell flat surface of the fuel cell of drawing 1, and (B) -- the thermal mapping of the unit-cell flat surface of the conventional fuel cell.
[Drawing 3]The graph which shows the temperature distribution of the lamination direction in near the center of the unit-cell flat surface in the sub stacks in comparison about the fuel cell A of drawing 1, and the conventional fuel cell B.
[Drawing 4]The graph which shows the battery capacity to operation time in comparison about the fuel cell A of drawing 1, and the conventional fuel cell B.
[Drawing 5]The perspective view showing typically a part of layered product of the 2nd embodiment of the fuel cell by this invention.
[Drawing 6]The perspective view showing typically a part of layered product of the 3rd embodiment of the fuel cell by this invention.
[Drawing 7]The perspective view showing the heat sink of drawing 6 typically.
[Drawing 8]The perspective view showing the structure of a fuel cell body.
[Explanations of letters or numerals]
1 -- Layered product
2 -- Clamping plate
3 -- Spacer
4 -- Gas manifold
5 -- Sealant
T1-T6 -- Constant temperature line
11a, 11b -- Cold plate
12a-12f -- Unit cell
13a-13f -- Separator board
14 -- Sub stacks
15 -- Refrigerant flowing path
16, 17 -- Reactant gas circulation way
21 -- Heat sink
22 -- Reactant gas circulation way
23 -- Seal part

[Translation done.]

* NOTICES *

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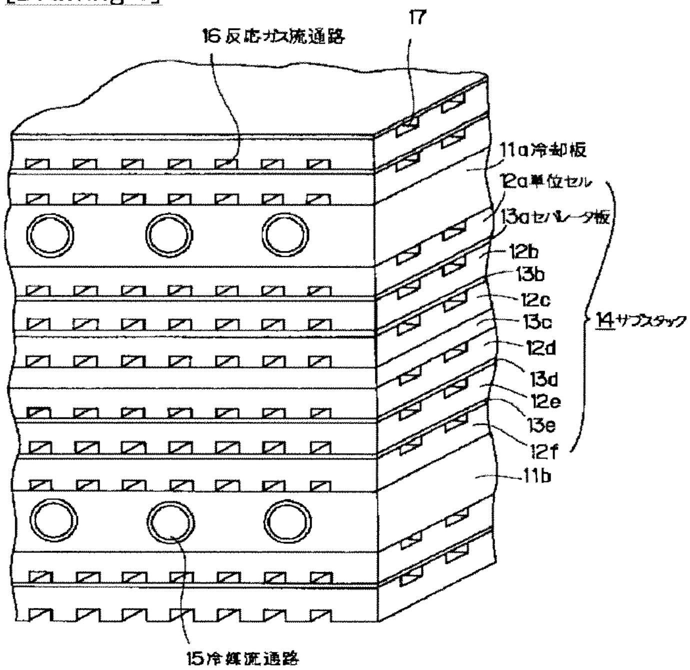
damages caused by the use of this translation.

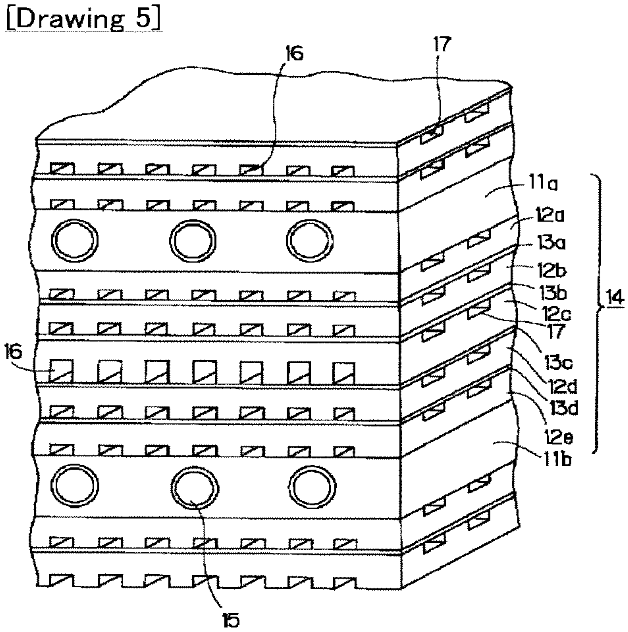
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

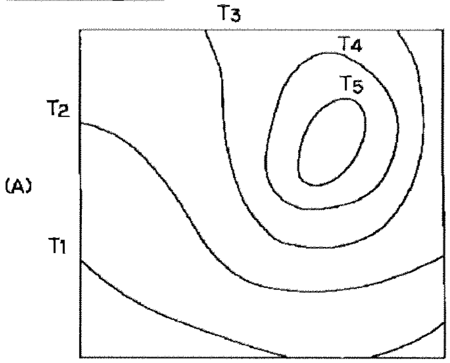
[Drawing 1]

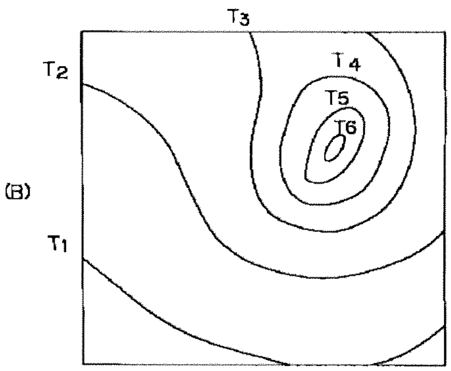


[Drawing 5]

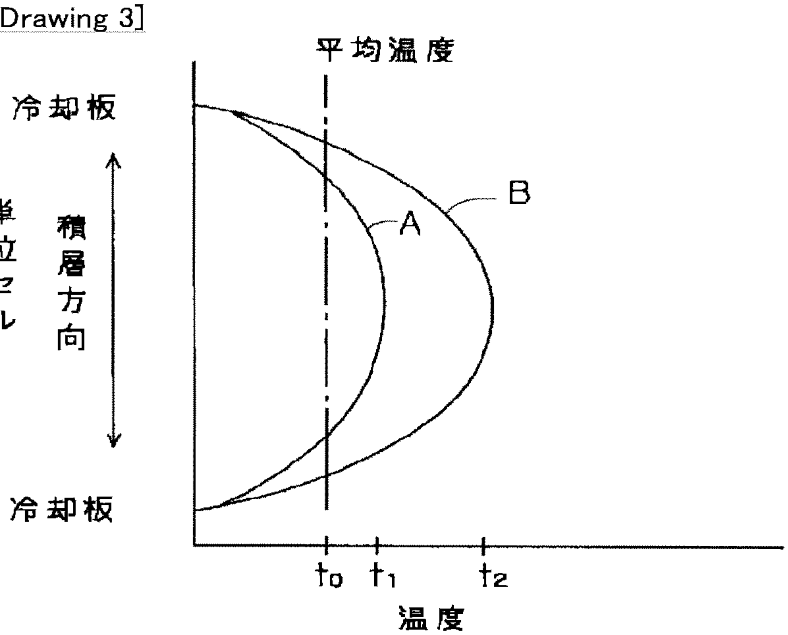


[Drawing 2]





[Drawing 3]



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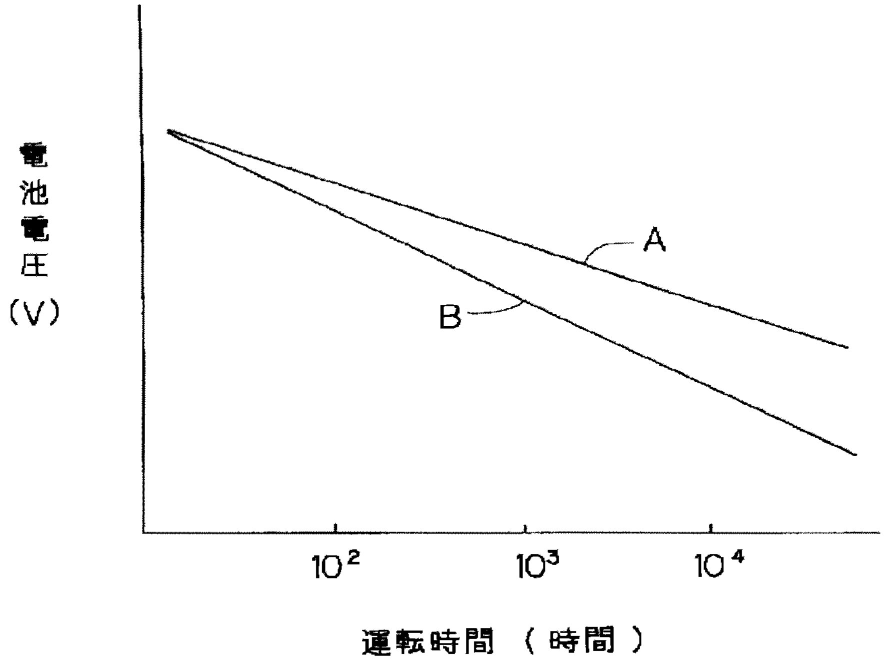
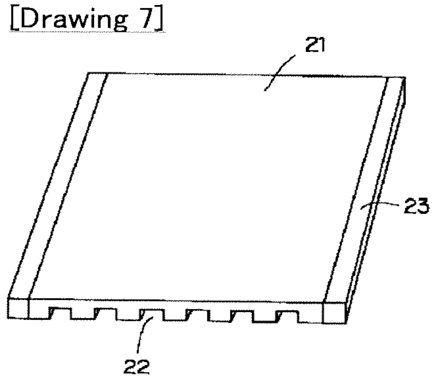
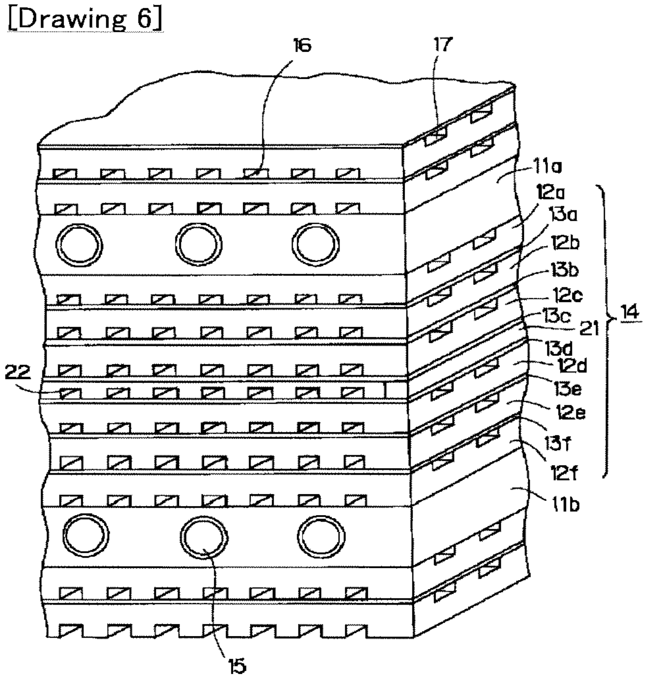


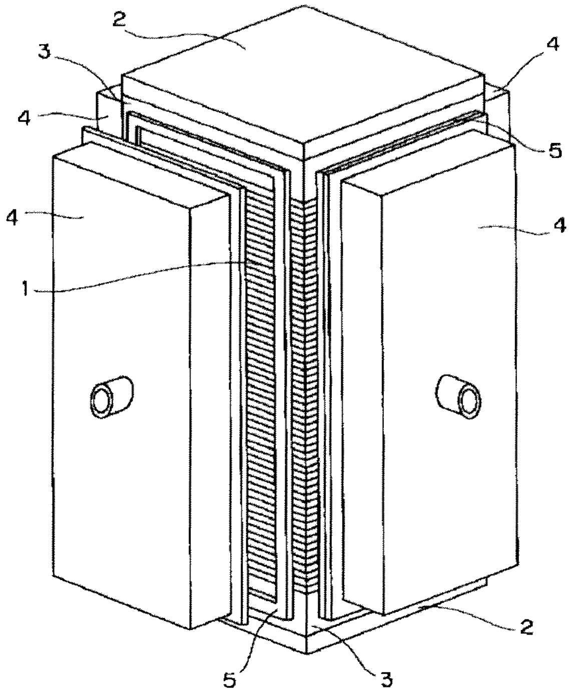
[Drawing 7]



[Drawing 6]



[Drawing 8]



[Translation done.]

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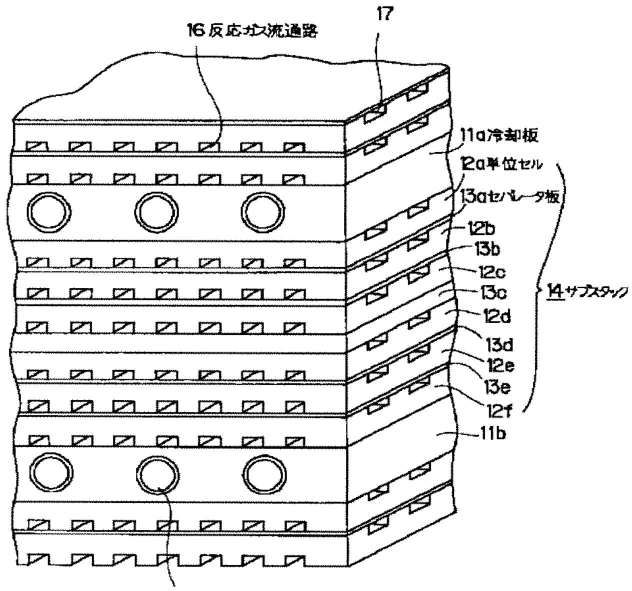
(54)【発明の名称】　燃料電池

(57)【要約】

【目的】　サブスタックの温度分布を均一化して、積層体全体の運転温度を許容温度により近い温度に設定可能とすることにより、発電効率に優れ、長期に渡って安定した高い電池性能を維持可能な、電池寿命の長い燃料電池を提供する。

【構成】　複数個の単位セル１２ａ～１２ｆとセパレータ板１３ａ～１３ｅを交互に積層してサブスタック１４を形成する。サブスタック１４と冷却板１１ａ，１１ｂとを交互に複数個積層して積層体を形成する。サブスタック１４の積層方向中央部のセパレータ板１３ｃの厚さを他の部分よりも厚くする。あるいは、サブスタック１４の積層方向中央部の単位セル１２ｃの反応ガス流通路１６の断面積またはガス接触面積を他の部分よりも大きくする。あるいは、サブスタックの積層方向中央部の単位セル１２ｃ，１２ｄ間に放熱板２１を介在させる。



【特許請求の範囲】

【請求項１】　電極基体の一方の面に触媒を担持させるとともに他方の面に反応ガス流通路を形成してなる一対の電極を、その触媒面を対向させて配置し、この一対の電極の触媒面間に電解質層を挟んで単位セルを形成し、この単位セルを複数個積層し、各単位セル間にセパレータ板をそれぞれ挿入してサブスタックを形成し、このサブスタックと冷却板とを交互に複数個積層して積層体を形成してなる燃料電池において、
前記サブスタックの積層方向中央部のセパレータ板の厚さを、他の部分のセパレータ板の厚さよりも厚くしたことを特徴とする燃料電池。

【請求項２】　電極基体の一方の面に触媒を担持させるとともに他方の面に反応ガス流通路を形成してなる一対の電極を、その触媒面を対向させて配置し、この一対の電極の触媒面間に電解質層を挟んで単位セルを形成し、この単位セルを複数個積層し、各単位セル間にセパレータ板をそれぞれ挿入してサブスタックを形成し、このサブスタックと冷却板とを交互に複数個積層して積層体を形成してなる燃料電池において、
前記サブスタックの積層方向中央部の単位セルの反応ガス流通路の断面積またはガス接触面積を、他の部分の単位セルの反応ガス流通路の断面積またはガス接触面積よりも大きくしたことを特徴とする燃料電池。

【請求項３】　電極基体の一方の面に触媒を担持させるとともに他方の面に反応ガス流通路を形成してなる一対の電極を、その触媒面を対向させて配置し、この一対の電極の触媒面間に電解質層を挟んで単位セルを形成し、この単位セルを複数個積層し、各単位セル間にセパレータ板をそれぞれ挿入してサブスタックを形成し、このサブスタックと冷却板とを交互に複数個積層して積層体を形成してなる燃料電池において、
前記サブスタックの積層方向中央部の単位セル間に少なくとも１個の放熱板を介在させたことを特徴とする燃料電池。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は燃料電池に係り、特に燃料電池積層体を構成する複数個の単位セル間の温度分布を均一化して、局部的な温度上昇を防止することにより、燃料電池の発電効率を向上するための技術に関する。

【０００２】

【従来の技術】燃料電池は、化学エネルギーを有する燃料を、電気化学プロセスで酸化させることにより、酸化反応に伴って放出されるエネルギーを直接電気エネルギーに変換する装置である。この燃料電池発電システムは、比較的小さな規模でも、発電の熱効率が４０～５０％にも達する、という特徴があるため、新鋭火力発電システムをはるかにしのぐ高効率の発電システムとして期待されている。また、近年大きな社会問題になっている公害要因であるＳＯｘ、ＮＯｘの排出が極めて少ない、発電装置内に燃焼サイクルを含まないので大量の冷却水を必要としない、振動が小さい、などの特徴があることから、騒音・排ガスなどの環境問題が少ないという利点もある。さらに、負荷変動に対して応答性が良い、原理的に高い変換効率が期待できると共に、発電と同時に熱も利用するコジェネシステムに向いている、などの優れた特徴があるため、その研究開発には期待と関心が寄せられ、実用化は目前に迫っている。

【０００３】この種の燃料電池としては、例えば、特開昭６０－９３７６５号公報に示されたものが知られている。すなわち、電池本体は、図８に示すように、発電のための単位セルとこの単位セルで発生する熱を排出するための冷却板を多数積層してなる積層体１、その積層体１を上下両側から締付ける締付板２、積層体１と締付板２の間に挿入するスペーサ３、反応ガス供給・排出用のガスマニホールド４、ガスマニホールド４と積層体１の間をシールするシール材５とを備えている。

【０００４】また、このような電池本体は、さらに、図示しない冷媒供給・排出用の冷媒マニホールド、図示しない電気出力取出し用ブスバーなどを備えている。そして、積層体１の単位セルには、ガスマニホールド４を介し、反応ガスである燃料ガスと酸化剤ガスが外部から供給・排出され、積層体１の冷却板には、冷媒マニホールドを介し、水などの冷媒が外部から供給・排出される。

【０００５】一般的に、上述のような燃料電池の積層体１は、複数個の単位セルを積層し、各単位セル間に反応ガスを区分するセパレータ板をそれぞれ挿入して一つのサブスタックを形成し、このようなサブスタックと冷却板とを交互に複数個積層して構成される。この場合、積層体１を構成する単位セルは、通常は、電極基体の一方の面に触媒を担持させるとともに他方の面に反応ガス流通路を形成してなる一対の多孔質電極を、その触媒面を対向させて配置し、この触媒面間に電解質層を挟んで形成される。そして、一方の電極を燃料極としてその背面に水素などの燃料ガスを接触させるとともに、他方の電極を酸化剤極としてその背面に酸素などの酸化剤ガスを接触させ、このときに起こる電気化学反応により発生する電気エネルギーを、上記一対の電極間から取り出すように構成される。また、冷却板には、冷媒流通路が形成され、ここに冷媒を流通させることによって、冷却板周辺の単位セルを冷却するように構成される。

【０００６】より詳細には、構造を容易化して信頼性や生産性を高める観点から、積層体１を構成する複数個の単位セルの外形とその反応ガス流通路の寸法形状、セパレータ板の寸法形状、および冷却板とその冷媒流通路の寸法形状などは、それぞれ全て規格・統一化される。また、電解質として一般に用いられているのは、リン酸などの酸性溶液である。さらに、単位セルの多孔質電極

は、通常は、電極基体としてカーボンペーパーのような多孔質炭素基体を使用し、この多孔質炭素基体の一方の面に貴金属触媒を担持させるとともに、他方の面に反応ガス流通路として多数の平行な溝を形成して構成される。

【０００７】

【発明が解決しようとする課題】ところで、以上のような従来の燃料電池においては、積層体１を構成する複数個の単位セル間の温度に格差を生じるため、最高温度を許容温度以下に設定した場合には、単位セルの大部分について必要以上に低温で運転しなければならず、その結果、発電効率が低くなるという問題がある。この点について、以下に説明する。

【０００８】すなわち、まず、前述したような単位セルの電気化学反応は、単位セルの運転温度が高いほど促進されるため、燃料電池の発電効率は、基本的には、単位セルの運転温度が高いほど大きくなる。しかしながら、単位セルの運転温度がある値を越えると、電気化学反応を促進する触媒の劣化や電解質の減少により電池性能が急激に低下し電池寿命が短くなる。このため、単位セル内の最高温度を、ある値以下に設定・保持する必要がある。

【０００９】その一方で、燃料電池の積層体１は、前述したように、複数個の単位セルと各単位セル間に挿入されたセパレータ板により構成されるサブスタックを、冷却板と交互に多数積層して構成されるが、サブスタック内の温度は、一般に不均一で三次元的な分布となる。具体的に、冷却板間のサブスタック内の単位セル平面の中心付近における積層方向の温度分布は、図３のＢに示すようになる。この図３のＢに示すように、サブスタックの積層方向端部から積層方向中央部に向かって単位セルの温度は傾斜的に高くなっている。そして、積層方向中央部の単位セル、すなわち、冷却板から最も遠い位置にある単位セルの温度が最も高くなっており、この最高温度 t_2 は、サブスタックの平均温度 t_0 に比べて極めて高くなっている。例えば、積層体に２００ｍＡ／ｃｍ^2 の負荷状態で一定利用率の反応ガス量を供給した場合に、平均温度 t_0 は２００℃であるのに対して、最高温度 t_2 は２１５℃まで上昇したことが確認されている。

【００１０】さらに、このような、積層方向中央部の単位セルの平面内の温度分布を等温線（Ｔ１～Ｔ６）で示すと、図２の（Ｂ）に示すようになる。この図２から明らかなように、単位セル中心付近は、等温線の間隔が小さく、すなわち温度勾配が大きくなっており、等温線Ｔ６内の狭い領域が他に比べて格段に高温の最高温度領域となる。そのため、従来の燃料電池では、この積層方向中央部の単位セルの狭い最高温度領域の温度（最高温度）を許容温度以下にするようにして、冷却水温度などの値を設定することになる。したがって、積層体全体の平均温度に比べて格段に高い温度を、許容温度以下に設定することになるため、サブスタックの積層方向端部側の多くの単位セルを必要以上に低温で運転する結果となる。すなわち、サブスタックを構成する複数個の単位セル間の温度差の大きさと最高温度領域を有する積層方向中央部の単位セル内の温度差の大きさに応じて、単位セルの大部分については、許容温度よりはるかに低い温度で運転する結果となり、このことが、発電効率の向上の支障となる。また、局部的な高温部における触媒の劣化により、長期に渡って連続運転した場合には、図４に示すように、電池性能が大きく低下してしまう。

【００１１】本発明は、以上のような従来技術の課題を解決するために提案されたものであり、その目的は、積層体のサブスタック中央部における局部的な高温部をなくし、サブスタックの温度分布を均一化して、積層体全体の運転温度を許容温度により近い温度に設定可能とすることにより、発電効率に優れ、長期に渡って安定した高い電池性能を維持可能な、電池寿命の長い燃料電池を提供することである。

【００１２】

【課題を解決するための手段】本発明の燃料電池は、電極基体の一方の面に触媒を担持させるとともに他方の面に反応ガス流通路を形成してなる一対の電極を、その触媒面を対向させて配置し、この一対の電極の触媒面間に電解質層を挟んで単位セルを形成し、この単位セルを複数個積層し、各単位セル間にセパレータ板をそれぞれ挿入してサブスタックを形成し、このサブスタックと冷却板とを交互に複数個積層して積層体を形成してなる燃料電池において、次のような特徴を有するものである。

【００１３】まず、請求項１に記載の燃料電池は、前記サブスタックの積層方向中央部のセパレータ板の厚さを、他の部分のセパレータ板の厚さよりも厚くしたことを特徴としている。また、請求項２に記載の燃料電池は、前記サブスタックの積層方向中央部の単位セルの反応ガス流通路の断面積またはガス接触面積を、他の部分の単位セルの反応ガス流通路の断面積またはガス接触面積よりも大きくしたことを特徴としている。さらに、請求項３に記載の燃料電池は、前記サブスタックの積層方向中央部の単位セル間に少なくとも１個の放熱板を介在させたことを特徴としている。

【００１４】

【作用】以上のような構成を有する本発明の作用は次の通りである。まず、請求項１に記載の燃料電池においては、サブスタックの積層方向中央部のセパレータ板の厚さを他の部分よりも厚くしたことにより、このセパレータ板によってその両側の単位セル間の積層方向の熱伝導を抑制し、その分だけ単位セルの平面方向の熱伝導を促進させることができる。この結果、最高温度領域を有する積層方向中央部の単位セル内の温度分布を均一化して、この単位セル内の最高温度領域の温度を低下させ、積層体全体の平均温度に近付けることができるため、積

層体を構成する複数個の単位セル間の温度分布を均一化することができる。したがって、積層方向中央部の単位セルの最高温度領域を許容温度以下に設定した場合に、積層体全体の運転温度を許容温度により近付けることができ、それにより、発電効率を向上することができる。また、局部的な高温部をなくすことができるため、触媒の劣化を抑制し、長期に渡って安定した高い電池性能を維持することができる。

【００１５】次に、請求項２に記載の燃料電池においては、サブスタックの積層方向中央部の単位セルの反応ガス流通路の断面積またはガス接触面積を他の部分よりも大きくしたことにより、この反応ガス流通路内の反応ガス流通によって積層方向中央部の単位セルを冷却することができる。この結果、最高温度領域を有する積層方向中央部の単位セルの温度を低下させ、積層体を構成する複数個の単位セル間の温度分布を均一化することができる。したがって、積層方向中央部の単位セルの最高温度領域を許容温度以下に設定した場合に、積層体全体の運転温度を許容温度により近付けることができ、それにより、発電効率を向上することができる。また、局部的な高温部をなくすことができるため、触媒の劣化を抑制し、長期に渡って安定した高い電池性能を維持することができる。

【００１６】さらに、請求項３に記載の燃料電池においては、サブスタックの積層方向中央部の単位セル間に放熱板を介在させたことにより、この放熱板によって積層方向中央部の単位セルを冷却することができる。この結果、最高温度領域を有する積層方向中央部の単位セルの温度を低下させ、積層体を構成する複数個の単位セル間の温度分布を均一化することができる。したがって、積層方向中央部の単位セルの最高温度領域を許容温度以下に設定した場合に、積層体全体の運転温度を許容温度により近付けることができ、それにより、発電効率を向上することができる。また、局部的な高温部をなくすことができるため、触媒の劣化を抑制し、長期に渡って安定した高い電池性能を維持することができる。

【００１７】

【実施例】

（１）第１実施例

以下には、請求項１に記載の発明による燃料電池の一実施例（第１実施例）について、図１乃至図４を参照して具体的に説明する。ここで、図１は、燃料電池の積層体の一部を模式的に示す斜視図である。また、図２は、図１の燃料電池と従来の燃料電池について、そのサブスタック内の積層方向中央部の単位セルの平面内の温度分布を比較的に等温線でそれぞれ示す図であり、図２の（Ａ）は図１の燃料電池の単位セル平面の温度分布図、（Ｂ）は従来の燃料電池の単位セル平面の温度分布図である。さらに、図３は、図１の燃料電池Ａと従来の燃料電池Ｂについて、そのサブスタック内の単位セル平面の中心付近における積層方向の温度分布を比較的に示すグラフ、図４は、図１の燃料電池Ａと従来の燃料電池Ｂについて、運転時間に対する電池性能を比較的に示すグラフである。

【００１８】まず、図１に示すように、隣接する冷却板１１ａ，１１ｂの間には、６個の単位セル１２ａ～１２ｆと５個のセパレータ板１３ａ～１３ｅとを交互に積層してなるサブスタック１４が配置されている。サブスタック１４を構成するセパレータ板１３ａ～１３ｅのうち、サブスタック１４の積層方向中央部の２個の単位セル１２ｃ，１２ｄの間に挿入された積層方向中央部のセパレータ板１３ｃの厚さは、他のセパレータ板１３ａ，１３ｂ，１３ｄ，１３ｅの厚さの３倍以上に厚くされている。なお、図中１５は、冷却板１１ａ，１１ｂに設けられた冷媒流通路であり、１６，１７は、単位セル１２ａ～１２ｆに設けられた反応ガス流通路である。

【００１９】以上のような構成を有する本実施例の作用は次の通りである。すなわち、燃料電池の運転時に、各単位セル１２ａ～１２ｆから発生した熱は、単位セル１２ａ～１２ｆとセパレータ板１３ａ～１３ｅで構成されるサブスタック１４の中を三次元的に移動し、サブスタック１４の両端にある冷却板１１ａ，１１ｂに吸収される。このとき、各単位セルでの発熱量は一般に不均一であるため、従来のように、セパレータ板１３ａ～１３ｅの厚さが等しい場合には、図２の（Ｂ）に示すように、積層方向中央部の単位セル１２ｃ，１２ｄの温度が最も高くなり、さらに、その単位セルの平面に、面積が狭く、積層体全体の平均温度よりも格段に高温の最高温度領域を生じてしまう。

【００２０】これに対して、本実施例においては、サブスタック１４の積層方向中央部のセパレータ板１３ｃの厚さを、他のセパレータ板１３ａ，１３ｂ，１３ｄ，１３ｅの厚さの３倍以上に厚くしているため、このセパレータ板１３ｃによってその両側の単位セル１２ｃ，１２ｄ間の積層方向の熱伝導を抑制し、その分だけ単位セル１２ｃ，１２ｄの平面方向の熱伝導を促進させることができる。そのため、図２の（Ａ）に示すように、積層方向中央部の単位セル１２ｃ，１２ｄ内の平面方向における局部的な高温部Ｔ６をなくし、温度分布を均一化して、この単位セル１２ｃ，１２ｄ内の最高温度領域の温度を、従来のＴ６からＴ５へと低下させ、積層体全体の平均温度に近付けることができる。

【００２１】ところで、仮に、全部のセパレータ板１３ａ～１３ｅを厚くした場合には、水平方向の熱伝導がさらに促進され、単位セルの平面方向の温度分布は一層均一化するが、その反面、積層体全体の高さが高くなり、輸送や耐震上不利になるだけでなく、積層方向の熱抵抗が大きくなり、必ずしもセル内の最高温度を下げることができるとは限らない。これに対して、図１に示す実施例のように、冷却板１１ａ，１１ｂ間の単位セルが偶数

個の場合、積層方向の熱伝導は中央部のセパレータを中心として上下に対称的に行われるため、中央部のセパレータ板のみを厚くしても、積層方向の熱抵抗の増加にはならず、前述したように、単位セルの平面方向の熱伝導促進の効果が有効に作用し、単位セルの最高温度を低下させることができる。

【００２２】したがって、本実施例においては、冷却水の温度および単位セルの発熱量が同じ場合、従来よりも単位セルの最高温度を低く押さえることができるため、サブスタック１４を構成する６個の単位セル１２ａ～１２ｆ間の温度分布を均一化することができる。すなわち、図３に示すように、本実施例の燃料電池Ａのサブスタック内の積層方向中央部の単位セルの最高温度t_1 は、従来の燃料電池Ｂの最高温度t_2 よりも低くなっており、最高温度t_1 とサブスタックの平均温度t_0との差は、従来よりも小さくなっている。例えば、サブスタックの積層方向における全ての単位セルとセパレータ板を同一規格とした従来の燃料電池と、サブスタックの積層方向中央部のセパレータ板の厚さを変えた本実施例の燃料電池とについて、それぞれの積層体に、２００ｍＡ／ｃｍ^2 の負荷状態で一定利用率の反応ガス量を供給したところ、従来の燃料電池では、前述したように、２００℃の平均温度t_0 に対して最高温度t_2 は２１５℃まで上昇したのに比べ、本実施例の燃料電池では、２００℃の平均温度t_0 に対する最高温度t_1 は２０５℃であった。

【００２３】このように、本実施例においては、サブスタック内における最高温度t_1 と平均温度t_0 との差を従来よりも小さくできるため、積層方向中央部の単位セル１２ｃ，１２ｄの最高温度t_1 を許容温度以下に設定した場合には、積層体全体の運転温度を従来よりも許容温度に近付けることができ、それにより、発電効率を従来よりも格段に向上することができる。また、サブスタックにおいて従来生じていた局部的な高温部をなくすことができるため、燃料電池を長期に渡って連続運転した場合には、図４に示すように、本実施例の燃料電池Ａは、従来の燃料電池Ｂに比べて格段に高い電池性能を維持できる。

【００２４】なお、前記第１実施例においては、冷却板１１ａ，１１ｂ間のサブスタック１４を６個の単位セル１２ａ～１２ｆと５個のセパレータ板１３ａ～１３ｅにて構成し、積層方向中央部の１個のセパレータ板１３ｃのみを他より厚くする例を示したが、冷却板間のサブスタックを奇数個とし、セパレータ板を偶数個として構成した場合には、中央の２個のセパレータ板を厚くしてもよい。すなわち、一般的に、温度が高くなる積層方向中央部の単位セル付近の１個または複数個のセパレータ板を厚くすることによって、このセパレータ板の両側の単位セルの平面方向の熱伝達を促進させることができるため、それにより、この単位セルの温度分布を均一化して、最高温度を従来より低下させ、積層体全体の平均温度に近付けることができる。

【００２５】（２）第２実施例

以下には、請求項２に記載の発明による燃料電池の一実施例（第２実施例）について、図５を参照して具体的に説明する。ここで、図５は、燃料電池の積層体の一部を模式的に示す斜視図である。なお、前記第１実施例と同一部分には同一符号を付し、説明を省略する。

【００２６】まず、図５に示すように、隣接する冷却板１１ａ，１１ｂの間には、５個の単位セル１２ａ～１２ｅと４個のセパレータ板１３ａ～１３ｄとを交互に積層してなるサブスタック１４が配置されている。サブスタック１４を構成する単位セル１２ａ～１２ｅのうち、サブスタック１４の積層方向中央部の１個の単位セル１２ｃについては、その一方の反応ガス流通路１６の溝の深さが、他の４個の単位セル１２ａ，１２ｂ，１２ｄ，１２ｅの対応する反応ガス流通路１６の溝の深さの２倍にされている。この溝の深さの際に伴い、中央部の単位セル１２ｃの厚さは、それ以外の単位セル１２ａ，１２ｂ，１２ｄ，１２ｅの厚さよりも厚くなっている。なお、単位セル１３ｃの他方の反応ガス流通路１７の溝の深さは、他の単位セル１２ａ，１２ｂ，１２ｄ，１２ｅの対応する反応ガス流通路１７の溝の深さと等しくされている。

【００２７】以上のような構成を有する本実施例の作用は次の通りである。すなわち、本実施例においては、サブスタック１４の積層方向中央部の単位セル１２ｃの反応ガス流通路１６の溝の深さを、他の単位セル１２ａ，１２ｂ，１２ｄ，１２ｅの溝の深さの２倍として、その断面積およびガス接触面積を大きくしているため、この単位セル１２ｃの反応ガス流通路１６の反応ガス流通によって、単位セル１２ｃを冷却することができる。そのため、前記第１実施例と同様に、積層方向中央部の単位セル１２ｃ内の平面方向における局部的な高温部をなくし、温度分布を均一化して、この単位セル１２ｃ内の最高温度領域の温度を、従来より低下させ、積層体全体の平均温度に近付けることができる。

【００２８】したがって、本実施例においても、前記第１実施例と同様に、冷却水の温度および単位セルの発熱量が同じ場合、従来よりも単位セルの最高温度を低く押さえることができるため、サブスタック１４を構成する５個の単位セル１２ａ～１２ｅ間の温度分布を均一化することができる。すなわち、図３に示すように、本実施例の燃料電池Ａのサブスタック内の積層方向中央部の単位セルの最高温度t_1は、従来の燃料電池Ｂの最高温度t_2 よりも低くなり、最高温度t_1 とサブスタックの平均温度t_0 との差が従来よりも小さくなる。例えば、サブスタックの積層方向における全ての単位セルの反応ガス流通路を同一規格とした従来の燃料電池と、サブスタックの積層方向中央部の単位セルの反応ガス流通路の溝

の深さを変えた本実施例の燃料電池とについて、それぞれの積層体に、２００ｍＡ／ｃｍ^2 の負荷状態で一定利用率の反応ガス量を供給したところ、従来の燃料電池では、前述したように、２００℃の平均温度ｔ$_0$ に対して最高温度ｔ$_2$ は２１５℃まで上昇したのに比べ、本実施例の燃料電池では、前記第１実施例と同様に、２００℃の平均温度ｔ$_0$ に対する最高温度ｔ$_1$ は２０５℃であった。

【００２９】このように、本実施例においても、前記第１実施例と同様に、サブスタック内における最高温度ｔ$_1$ と平均温度ｔ$_0$ との差を従来よりも小さくできるため、積層方向中央部の単位セル１２ｃの最高温度ｔ$_1$ を許容温度以下に設定した場合には、積層体全体の運転温度を従来よりも許容温度に近付けることができ、それにより、発電効率を従来よりも格段に向上することができる。また、サブスタックにおいて従来生じていた局部的な高温部をなくすことができるため、燃料電池を長期に渡って連続運転した場合には、前記第１実施例と同様、図４に示すように、本実施例の燃料電池Ａは、従来の燃料電池Ｂに比べて格段に高い電池性能を維持できる。

【００３０】なお、前記第２実施例においては、積層方向中央部の単位セル１２ｃの一方の反応ガス流通路１６の溝の深さを大きくした例を示したが、この他にも、溝深さ・溝幅を同時に大きくした形状、溝幅のみを大きくした形状などが可能である。すなわち、請求項２の発明では、積層方向中央部の単位セルについて、その反応ガス流通路の断面積またはガス接触面積を大きくするようなあらゆる形状変更が可能であり、前記実施例と同様の作用効果を得られるものである。

【００３１】（３）第３実施例

以下には、請求項３に記載の発明による燃料電池の一実施例（第３実施例）について、図６および図７を参照して具体的に説明する。ここで、図６は、燃料電池の積層体の一部を模式的に示す斜視図、図７は、図６の放熱板を模式的に示す斜視図である。なお、前記第１、第２実施例と同一部分には同一符号を付し、説明を省略する。

【００３２】まず、図６に示すように、隣接する冷却板１１ａ，１１ｂの間には、６個の単位セル１２ａ～１２ｆを積層してなるサブスタック１４が配置されている。このサブスタック１４の積層方向中央部の２個の単位セル１２ｃ，１２ｄの間には、１個の放熱板２１が挿入されている。この放熱板２１は、単位セルの多孔質電極の電極基体と同様の多孔質炭素基体から構成されている。そして、このような多孔質性の放熱板２１の片面には、図７に示すように、反応ガス流通路２２が形成されており、この反応ガス流通路２２の両側に相当する放熱板２１端部には、シール部２３が設けられ、反応ガスのリークを防止できるようになっている。また、隣接する各単位セル間および、単位セル１２ｃ，１２ｄと放熱板２１との間には、６個のセパレータ板１３ａ～１３ｆがそれぞれ挿入されている。

【００３３】以上のような構成を有する本実施例の作用は次の通りである。すなわち、本実施例においては、サブスタック１４の積層方向中央部の単位セル１２ｃ，１２ｄ間に、放熱板２１を挿入したため、この放熱板２１によって、その両側の単位セル１２ｃ，１２ｄを冷却することができる。特に、本実施例においては、放熱板２１に反応ガス流通路２２を設けたため、この反応ガス流通路２２の反応ガス流通によって、冷却効率をさらに高くすることができる。そのため、前記第１、第２実施例と同様に、積層方向中央部の単位セル１２ｃ，１２ｄ内の平面方向における局部的な高温部をなくし、温度分布を均一化して、この単位セル１２ｃ，１２ｄ内の最高温度領域の温度を従来より低下させ、積層体全体の平均温度に近付けることができる。

【００３４】したがって、本実施例においても、前記第１、第２実施例と同様に、冷却水の温度および単位セルの発熱量が同じ場合、従来よりも単位セルの最高温度を低く押さえることができるため、サブスタック１４を構成する６個の単位セル１２ａ～１２ｆ間の温度分布を均一化することができる。すなわち、図３に示すように、本実施例の燃料電池Ａのサブスタック内の積層方向中央部の単位セルの最高温度ｔ$_1$ は、従来の燃料電池Ｂの最高温度ｔ$_2$ よりも低くなり、最高温度ｔ$_1$ とサブスタックの平均温度ｔ$_0$ との差が従来よりも小さくなる。例えば、サブスタック内に放熱板を持たない従来の燃料電池と、サブスタックの積層方向中央部に放熱板を配置した本実施例の燃料電池とについて、それぞれの積層体に、２００ｍＡ／ｃｍ^2 の負荷状態で一定利用率の反応ガス量を供給したところ、従来の燃料電池では、前述したように、２００℃の平均温度ｔ$_0$ に対して最高温度ｔ$_2$ は２１５℃まで上昇したのに比べ、本実施例の燃料電池では、前記第１、第２実施例と同様に、２００℃の平均温度ｔ$_0$ に対する最高温度ｔ$_1$ は２０５℃であった。

【００３５】このように、本実施例においても、前記第１、第２実施例と同様に、サブスタック内における最高温度ｔ$_1$ と平均温度ｔ$_0$ との差を従来よりも小さくできるため、積層方向中央部の単位セル１２ｃ，１２ｄの最高温度ｔ$_1$ を許容温度以下に設定した場合には、積層体全体の運転温度を従来よりも許容温度に近付けることができ、それにより、発電効率を従来よりも格段に向上することができる。また、サブスタックにおいて従来生じていた局部的な高温部をなくすことができるため、燃料電池を長期に渡って連続運転した場合には、前記第１、第２実施例と同様、図４に示すように、本実施例の燃料電池Ａは、従来の燃料電池Ｂに比べて格段に高い電池性能を維持できる。さらに、本実施例の放熱板２１は、単位セルの多孔質電極の電極基体と同様の多孔質炭素基体を使用しているため、電解質を含浸保持する電解質リザーバーとしての機能をも有する。

【００３６】なお、前記実施例においては、放熱板２１に反応ガス流通路２２を設けたが、請求項３の発明は、これに限定されるものではなく、反応ガス流通路２２を設けない構成も可能であり、その場合にも十分な作用効果が得られる。また、１つのサブスタック１４内に放熱板２１を２個以上設ける構成も可能である。

【００３７】

【発明の効果】以上説明したように、本発明の燃料電池は、サブスタックの積層方向中央部のセパレータ板の厚さを他の部分より厚くするか、あるいは、サブスタックの積層方向中央部の単位セルの反応ガス流通路の断面積またはガス接触面積を他の部分よりも大きくするか、あるいは、サブスタックの積層方向中央部の単位セル間に放熱板を介在させるという簡単な構成の改良により、積層体のサブスタック中央部における局部的な高温部をなくし、サブスタックの温度分布を均一化することができる。したがって、積層体全体の運転温度を許容温度により近い温度に設定可能できるため、従来に比べて発電効率に優れ、長期に渡って安定した高い電池性能を維持可能な、電池寿命の長い燃料電池を提供することができる。

【図面の簡単な説明】

【図１】本発明による燃料電池の第１実施例の積層体の一部を模式的に示す斜視図。

【図２】図１の燃料電池と従来の燃料電池について、そのサブスタック内の積層方向中央部の単位セルの平面内の温度分布を比較的に等温線でそれぞれ示す図であり、（Ａ）は図１の燃料電池の単位セル平面の温度分布図、＊（Ｂ）は従来の燃料電池の単位セル平面の温度分布図。

【図３】図１の燃料電池Ａと従来の燃料電池Ｂについて、そのサブスタック内の単位セル平面の中心付近における積層方向の温度分布を比較的に示すグラフ。

【図４】図１の燃料電池Ａと従来の燃料電池Ｂについて、運転時間に対する電池性能を比較的に示すグラフ。

【図５】本発明による燃料電池の第２実施例の積層体の一部を模式的に示す斜視図。

【図６】本発明による燃料電池の第３実施例の積層体の一部を模式的に示す斜視図。

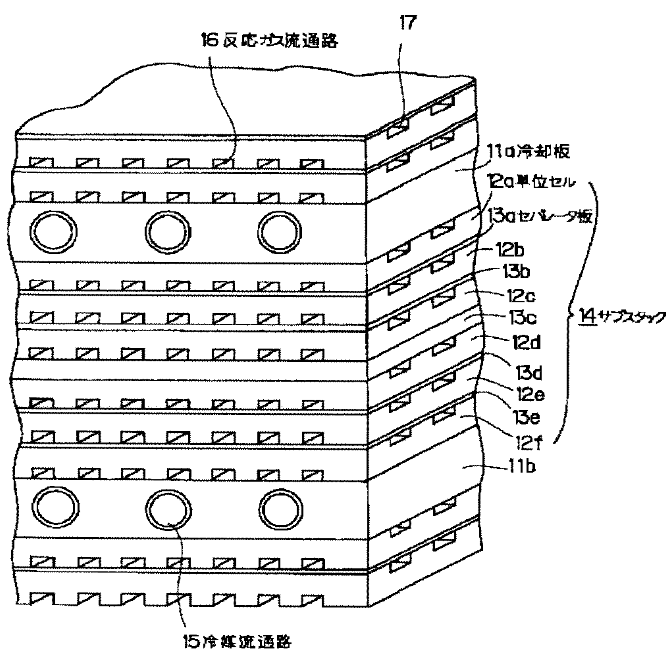
【図７】図６の放熱板を模式的に示す斜視図。

【図８】燃料電池本体の構造を示す斜視図。

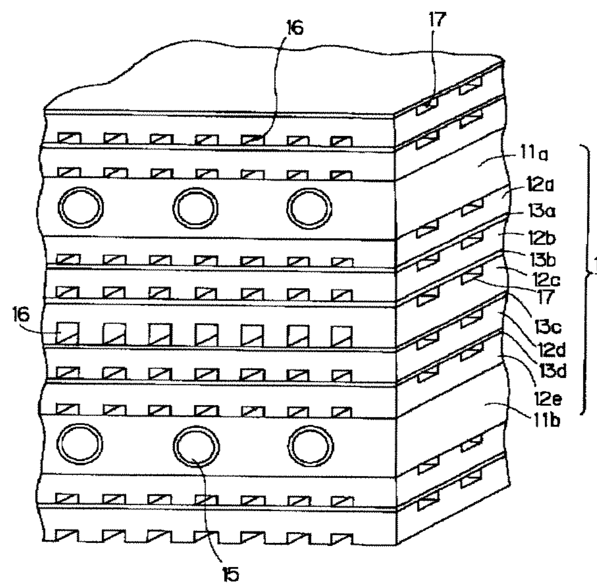
【符号の説明】

１…積層体
２…締付板
３…スペーサ
４…ガスマニホールド
５…シール材
Ｔ１～Ｔ６…等温線
１１ａ，１１ｂ…冷却板
１２ａ～１２ｆ…単位セル
１３ａ～１３ｆ…セパレータ板
１４…サブスタック
１５…冷媒流通路
１６，１７…反応ガス流通路
２１…放熱板
２２…反応ガス流通路
２３…シール部

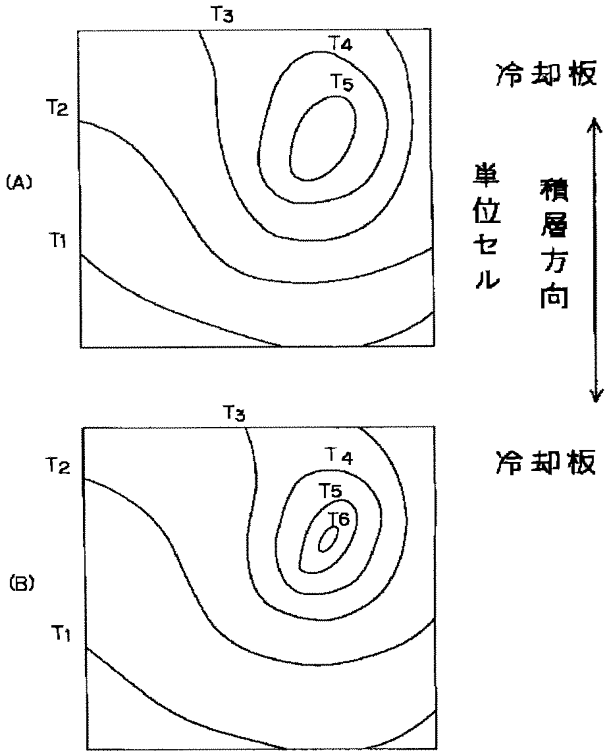
【図１】



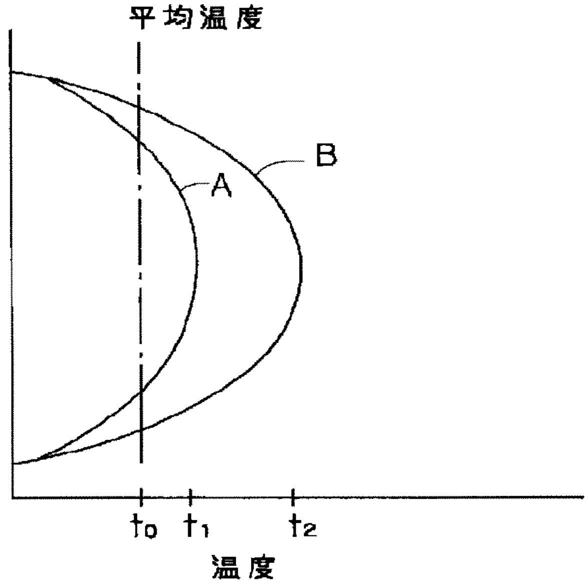
【図５】



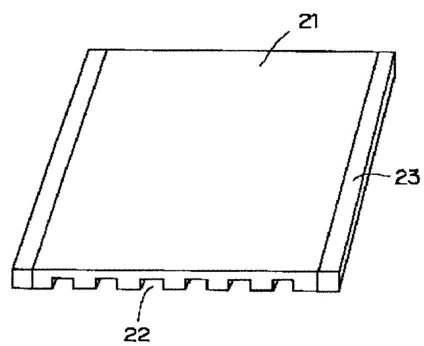
【図2】


(A)
T1
T2
T3
T4
T5
(B)
T1
T2
T3
T4
T5
T6
冷却板
単位セル
積層方向
冷却板

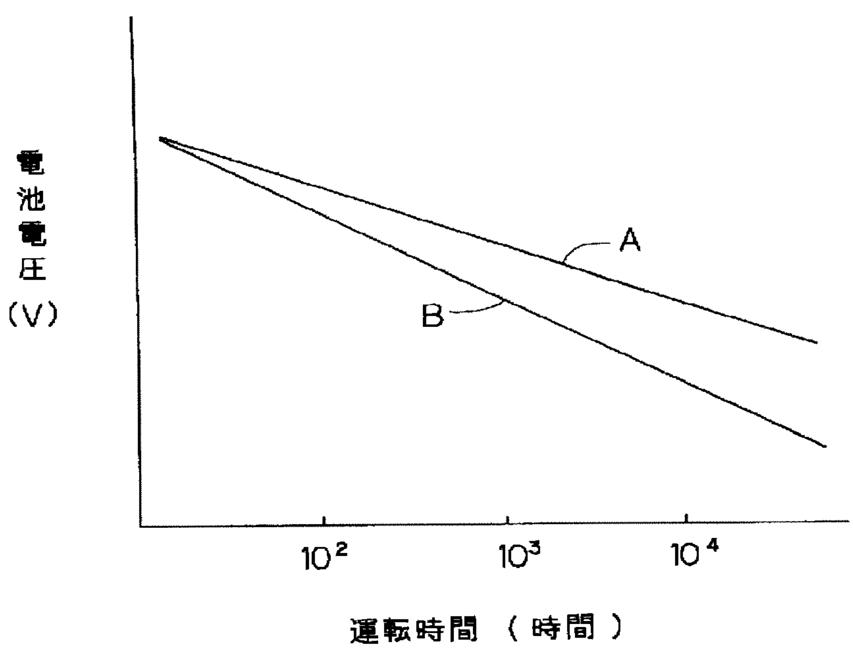
【図3】


平均温度
A
B
t_0
t_1
t_2
温度

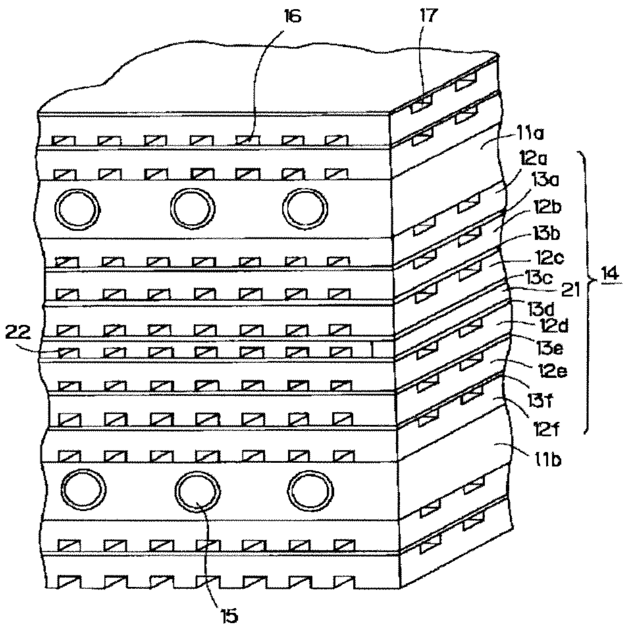
【図7】


21
23
22

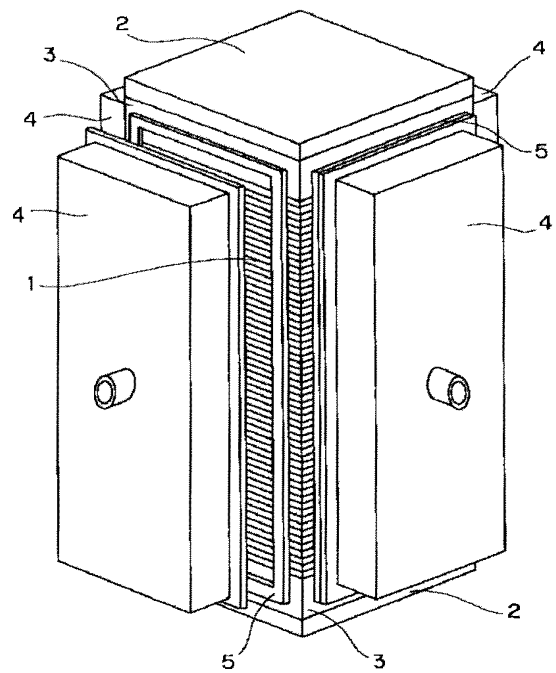
【図4】


電池電圧
(V)
A
B
10^2
10^3
10^4
運転時間 （時間）

【図６】


16
17
11a
12a
13a
12b
13b
12c
13c
21
14
13d
12d
22
13e
12e
13f
12f
11b
15

【図８】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